

# Wildlife Ecology



## The Browntail Moth.

### Background.



The browntail moth (*Euproctis chrysorrhoea*), a European species, was accidentally introduced into the United States in the late 1890s; by 1913, the insect had spread to all of the New England states, as well as New Brunswick and Nova Scotia in eastern Canada. Since then, natural controls have led to a slow decrease in the moth's North American populations and significant browntail communities now only exist on a few islands in Casco Bay off the Maine coast and in Cape Cod National Seashore. The invasive moth causes an allergic reaction, similar to the itchy rash caused by poison ivy, in people who come into contact with adults, larvae, webs or just molted body hairs that are carried by the wind. In addition, the moth's preferred foods are beach plum (*Prunus maritima*), shadbush (*Amelanchier* sp.), oak (*Quercus* sp.) and salt spray rose (*Rosa rugosa*), species that comprise a large part of CACO's dune flora. Because these plants play an important role in stabilizing dune ecosystems and in supporting state listed rare *Lepidoptera* (at least 28 rare species have been collected in the CACO dunes (Mello, 1986)), browntail moth feeding habits pose a potential threat to this sensitive ecological community. Observations of feeding larvae indicate that some host plants may become defoliated as a result of moth infestation, although the effects of defoliation on plant growth, vigor and long-term survival remain unknown.

Although many browntail surveys and control efforts have been conducted within CACO over the last thirty years (see, for example, Snowden, 1986; Leonard, 1986; Samora and Whatley, 1987; and Anderson, 1989), virtually no quantitative data exist to indicate trends in the moth's distribution or abundance on the outer Cape. Only qualitative information on the perimeter of the past infestation is available, and associated census data are fragmentary at best. Survey methods are poorly documented, and survey tools and methodologies for estimating the density and distribution of this non-native insect remain inadequate and expensive. Browntail monitoring, implemented both immediately and over time as part of a long-term monitoring program, is needed in order to determine this insect's impact on native ecosystems.

### Research Needs.

**Monitor Moths:** The University of Massachusetts is currently conducting a study of browntail moth ecology, with focuses on both the natural factors controlling browntail population dynamics and possible management methods. Following the 2002 completion of this study, annual surveys of browntail moth distribution and abundance on the outer Cape are needed in order to monitor the movement and severity of CACO's moth infestation over time.

## **The Browntail Moth, continued.**

Study Browntail Impacts on Native Vegetation: Long-term monitoring plots need to be established to monitor host plant vigor, growth rates and survival, both in and outside of habitats containing browntail moths. Detailed information about browntail moth abundance in the test and control plots should be collected to determine if relationships exist between the various measures of moth abundance and damage to host plants, and to correlate the degree of defoliation with any associated impacts on plant growth and survival.

### **Research Cited.**

Anderson. 1989. Determination of the efficacy of clipping browntail moth hibernacles as a means of population control. Unpublished report, Cape Cod National Seashore. South Wellfleet, MA.

Leonard, D.E. 1986. Browntail moth defoliation study, Cape Cod National Seashore. USDI - NPS Office of Scientific Studies, North Atlantic Region, Report OSS 88-01.

Mello, M.J. 1986. Survey of non-target species of *Lepidoptera* in areas of browntail moth infestations in the Cape Cod National Seashore. Center for Coastal Studies, Provincetown, MA.

Samora, B. and M. Whatley. 1986. Resource Management Plan for Cape Cod National Seashore. Cape Cod National Seashore, South Wellfleet, MA.

Snowden, P. 1986. Biological evaluation of the browntail moth in 1985 on Cape Cod National Seashore. U.S. Department of Agriculture Forest Service NE Region Mimeo.

## Bullfrog Range Expansion.

### Background.

When Lazell published his 1960s observations on the distribution of reptiles and amphibians on the outer Cape, bullfrogs (*Rana catesbeiana*) were restricted to the upper Cape, with one introduced group outside the boundaries of Cape Cod National Seashore in South Wellfleet. Today, however, bullfrogs are widely distributed throughout kettle ponds, temporary vernal pools and streams at least as far north as Truro. Additionally, although they were thought to be excluded from highly acidic habitats (pH < 5; see Freda, 1986), they seem to occur and breed quite successfully in CACO ponds with pH levels around 4.5. The absence of acid-tolerant green frogs (*Rana clamitans*) from these sites further suggests that they, and perhaps other native fauna, have been displaced by the larger predatory bullfrogs. Recent observations of bullfrogs in a number of vernal pools are of particular concern because species in these seasonal wetland communities have evolved over the last 10,000 years without large anuran predation, and are thus highly vulnerable to elimination by this invasive species. Research on the causes and effects of bullfrog expansion on the outer Cape is critically needed in order to develop effective management strategies for the protection of native amphibian species and for the preservation of CACO's aquatic biodiversity.



### Research Needs.

A survey of bullfrog distribution on the entire outer Cape peninsula from Eastham to Provincetown is needed, followed by an examination of their ecological impact on faunal communities in CACO ponds and vernal pools. Using biological and chemical water quality data derived from other projects, the pattern of occurrence should be analyzed, with special attention given to water bodies within the present bullfrog range that do not have bullfrog populations and bodies of water that are on the margins of the present range. Emphasis should be placed on inter-species relations; however, the influences of aquatic chemistry and vegetative cover should also be investigated to explain the mechanism and possible limits of range expansion. Impacted native aquatic species should be identified, and field observation and analysis supplemented by experimental study in the lab, if necessary, to confirm hypotheses that are critical to the development of management strategies for bullfrog control and native species preservation.

### Research Cited.

Freda, J. 1986. The influence of acidic pond water on amphibians: A review. *Water, Air and Soil Pollution*, 30: 439-450.

Lazell, J.D. Jr. 1972. This Broken Archipelago: Cape Cod and the Islands' Amphibians and Reptiles. Quadrangle. New York, NY.





## **Freshwater Fish.**

### **Background.**

Cape Cod National Seashore contains a great diversity of freshwater aquatic habitats, including twenty kettle ponds, ten inter-dune ponds, one brackish impoundment and two rivers, that support about 15 species of freshwater and anadromous fishes.



These freshwater communities are subject to a variety of human influences that may be impacting the species composition and abundance of native fish populations. The Massachusetts Division of Fisheries and Wildlife (MDFW) maintains an active fishery enhancement program, which includes stocking waters with non-native fish and, in the past, liming kettle ponds. Recreational fishing for trout, bass and other game species is a very

popular activity within Cape Cod National Seashore, and is often accompanied by the release of non-native baitfish into ponds. Non-native predatory fish probably consume native species and may also compete with native fish for resources. Water quality is threatened by passive water recreation and by extensive residential development along pond and river shorelines. Additionally, several different entities with different resource objectives have jurisdiction over the management of freshwater habitats within the CACO boundary.

Given the potential cumulative impacts of these influences, native fish populations may be seriously threatened. However, our ability to protect these species is at present severely hampered by a lack of baseline data on native freshwater fish. The MDFW has only sporadically sampled game fish, and only in the last two years have systematic freshwater fish surveys been initiated in Cape Cod National Seashore. A complete inventory of freshwater fish, followed by long-term monitoring, is necessary in order to identify and understand the issues facing aquatic resources within the park.

### **Research Needs.**

A complete fisheries inventory of all freshwater habitats at CACO is currently underway through a cooperative agreement with the University of Massachusetts, Cooperative Fish Research Unit, and the United States Geological Survey-Biological Resources Division. Based on the data acquired in this study, a catalog of the occurrence, relative abundance and diversity of fish found within CACO's freshwater habitats will be developed, as well as species/habitat models for freshwater fish within the 20 kettle ponds and a protocol for continued monitoring. Long-term monitoring of freshwater habitats, with special emphasis on kettle ponds and estuaries, is needed in order to track changes in CACO's native fish populations over time.



## The Gypsy Moth.

### Background.

The gypsy moth (*Lymantria dispar*) was accidentally introduced into New England in the 1860s by a Massachusetts entomologist with a misinformed silk-making scheme.



Since then, these invasive caterpillars have become a serious problem throughout much of the Northeast and even parts of the Midwest, resulting in the defoliation of millions of acres of hardwood forest, as well as significant tree mortality. Larvae prefer oaks (*Quercus* sp.), but will also feed on other species, including gum (*Eucalyptus* sp.), maple (*Acer* sp.), sassafras (*Sassafras* sp.) and, in severe infestations, beech (*Fagus* sp.), white cedar (*Chamaecyparis thyoides*) and pine (*Pinus* sp.). Outbreaks at Cape Cod National Seashore have been cyclical, with the last “high” period occurring in the mid-1980s. Up until 1965, gypsy moths on the outer Cape were treated annually with pesticides, but current management activity is limited to yearly population monitoring.

### Research Needs.

The United States Forest Service (USFS) coordinates annual nationwide gypsy moth monitoring using a variety of sampling techniques, including traps, burlap bands and aerial surveys. Gypsy moth populations appear to be on the rise in Massachusetts, and continued monitoring using the USFS methods is necessary in order to track changes in the local abundance of this devastating invasive species and to formulate park-specific gypsy moth management actions.





## Hunting Impacts.

### Background.

The legislation that established Cape Cod National Seashore allows for hunting within the park, and species most commonly harvested in CACO include white-tailed deer (*Odocoileus virginianus*), cottontail rabbit (*Sylvilagus floridanus* and *S. transitionalis*), ring-necked pheasant (*Phasianus colchicus*; released yearly for hunting on CACO lands by the Massachusetts Division of Fisheries and Wildlife), Canada geese (*Branta canadensis*) and a large variety of other waterfowl. In order to maintain consistent safety regulations and bag limits, CACO has adopted the hunting regulations of the Commonwealth of Massachusetts (Massachusetts Division of Fisheries and Wildlife, 1990).



Little is known about the populations of, and levels of harvest experienced by, hunted animals within the park. Data on historic and current harvest levels in the park do not exist, nor has there been any effort to monitor population levels of hunted species. Consequently, the impacts of hunting on CACO ecosystems remain largely unknown. Small game hunting may compete with native predators and the possibility that such competition causes predators to shift to other prey, including state listed rare shorebirds, needs to be investigated.

### Research Needs.

A multi-year study is needed to evaluate the ecological impacts of hunting at CACO. Data on harvest levels and hunting efforts by species should be collected, and long-term monitoring of hunted species initiated in order to detect population trends in correlation with harvest data. If it is found that hunting depresses populations of small game species, ecological studies of native predators such as the great horned owl (*Bubo virginianus*), red fox (*Vulpes vulpes*) and coyote (*Canis latrans*) should be undertaken to quantify their feeding habits and to determine the extent to which hunting competes with them for prey, and the extent to which these native predators may shift their foraging to other CACO species, including state listed rare shorebirds.

### Research Cited.

Massachusetts Division of Fisheries and Wildlife. 1990. Abstracts of the 1990 Fish & Wildlife Laws. Massachusetts Division of Fisheries and Wildlife, Boston, MA.



## Marsh-Dwelling Shorebirds.

### Background.

The estuaries and salt marshes of Cape Cod National Seashore are important breeding, stopover and wintering areas for a number of migratory shorebird species. In general, marsh-dwelling shorebirds concentrate where feeding efficiency is greatest and thus where invertebrate prey density or availability is highest, factors that are heavily influenced by sediment characteristics (Roman and Able, 1989; Brown, 1994; Grandy, 1972). Use of shallow water estuarine habitats by migrating shorebirds is also affected by a number of other habitat variables, including water salinity, depth and frequency of flooding, heterogeneity of the plant community, competition between bird species and the history of human impact in any given area.

Human activities have been shown to adversely affect avian populations in many ways, including altering distribution, habitat use and foraging patterns and increasing bird energy expenditures. The spatial distribution and volume of estuarine marshes that have sustained human-induced loss or degradation are, additionally, more susceptible to sea level rise and storm events, with corresponding adverse affects on waterbirds. Human-induced reductions in water level and salinity, like those in many CACO salt marshes, have also lead to vigorous expansion of common reed (*Phragmites australis*), which in turn has resulted in low breeding bird diversity and abundance. Finally, Atlantic oyster (*Crassostrea gigas*) and other shellfish culture alters birds' spatial habitat structure by introducing shellfish, racks, stakes, culture bags, marker poles and other equipment into open tidal flats. Research conducted to date on the ecosystem effects of aquaculture has been limited to studies of effects on sediment and benthic infauna; effects of oyster culture on bird populations have been minimally addressed (Kelly et al., 1996), but more comprehensive research is necessary to determine the impacts of aquaculture on shorebird populations in CACO.

### Research Needs.

**Monitor Migrant Shorebirds:** Basic seasonal abundance data on migratory waterbird populations is fundamental to assessing the effects of aquaculture and chronic pollution, as well as catastrophic natural and anthropogenic events such as hurricanes and oil spills, on these bird communities. A protocol for measuring spatial and temporal patterns in frequency of occurrence, species richness, relative density and habitat use of waterbird assemblages in estuarine and brackish salt marshes is currently being developed with the United States Geological Survey. When integrated with other components of CACO's long-term ecological monitoring program, data acquired through the implementation of this protocol should allow managers to assess the impact of both natural and anthropogenic actions on bird use of wetlands for breeding, migration rest stops and non-breeding summering or wintering. Moreover, these data should be useful for predicting and evaluating the success of adaptive management actions such as salt marsh habitat restoration.

## Marsh-Dwelling Shorebirds, continued.

Evaluate the Impacts of Aquaculture on Fisheries and Shorebird Habitat: The use of intertidal mud flats by fish (high tide) and migratory shorebirds (low and high tide) in relation to aquaculture operations within CACO needs to be investigated. Specific issues to be addressed include:

1. the selection or avoidance of aquaculture areas by fish and migrant shorebirds during each season;
2. differences in fish and shorebird diversity between open tidal flats and aquaculture areas;
3. temporal and spatial variation of fish and shorebird abundance on open tidal flats and aquaculture areas; and
4. intraseasonal shifts in the use of tidal flats and aquaculture areas as compared with overall abundance changes at specific sites, such as Nauset Marsh and Wellfleet Bay.

(See related project descriptions under “Red Fox, Small Mammal Prey and Shorebird Nest Predation,” “Shorebirds” and, in the Aquatic Ecology chapter, “Aquaculture Impacts on Estuarine Ecosystems.”)

### Research Cited.

Brown, Jennifer M. 1994. Species composition, migration chronology, and habitat use of water-birds at Cape Cod National Seashore. Master’s Thesis, University of Rhode Island.

Grandy, John W. IV. 1972. Winter colony of maritime black ducks (*Anas Rubripes*) in Massachusetts with special reference to Nauset Marsh, Orleans, Eastham. Unpublished doctoral thesis, University of Massachusetts.

Kelly, J.P., J.G. Evens, R.W. Stallcup and D. Wimpfheimer. 1996. Effects of aquaculture on habitat use by wintering shorebirds in Tomales Bay, California. *California Fish and Game*, 82, 160-174.

Roman, C. and K. Able. 1989. An ecological analysis of Nauset Marsh, Cape Cod National Seashore. NPS CRU, Rutgers University, New Brunswick, NJ.

## The Northern Diamondback Terrapin.

### Background.



Presently, there are only seventeen known marsh systems in Massachusetts that are home to the Northern diamondback terrapin (*Malaclemys terrapin*), a medium-sized salt marsh turtle that reaches its northern distribution limits in Cape Cod National Seashore. The diamondback terrapin is listed as “threatened” by the Massachusetts Division of Fisheries and Wildlife, with the state’s largest terrapin population located in and around CACO.

Driven to the brink of extinction in Massachusetts by a gourmet taste for terrapin soup, the turtle now faces a different set of challenges. Although the harvest of diamondbacks is now illegal in Massachusetts, the species continues to experience high nest mortality and population decline as a result of human disruption and environmental degradation. Deep ruts created by off-road vehicles (ORVs) may trap migrant hatchlings, increasing both their chances of getting crushed by vehicles and their vulnerability to predation by gulls and crows, who have been observed standing on the edges of ORV tire tracks and scooping up baby turtles as they get caught in the ruts. ORVs also interfere with the nesting patterns of female turtles, who crawl towards high dunes with the intention of laying their eggs but return to the water at the slightest hint of threatening activity. This “false nesting,” which may also be prompted by beach-goers and people walking on the dunes, disrupts the egg-laying process and reduces the viability of the clutch by prolonging the length of time that the eggs are retained by their mothers. Reduction of salt marsh habitat and alteration of water composition quality caused by dredging and channelization, loss of sandy beach habitat to erosion and pollution, and destruction of dune nesting areas also contribute to the decline of the Northern diamondback terrapin in Massachusetts, as do natural processes like the infiltration of rootlets from beach grass rhizomes into nests and eggs, mammalian predation and maggot parasitism.

Terrapin nesting surveys have been conducted on the outer Cape periodically since 1982; however, no in-depth terrapin studies have been completed since 1991. An up-to-date survey assessing the status and trends of the terrapin population, as well as detailing nest sites and nesting success, is needed to evaluate the need for further management actions to protect the Northern diamondback terrapin from extinction.

### Research Needs.

A comprehensive field study of Northern diamondback terrapins in Wellfleet Bay is currently underway with the Massachusetts Audubon Society. Following this survey’s completion, long-term monitoring of the species is needed in order to track population changes over time and to evaluate management actions designed to protect this threatened species.





## Off-Road Vehicle Traffic Impacts on Beach Fauna.



### Background.

Cape Cod National Seashore encompasses forty miles of pristine sandy barrier beaches and spits that attract millions of visitors every year, as well as diverse and, in some cases, rare wildlife communities. Because off-road vehicle (ORV) use on beaches predates the establishment of CACO in 1961, the enabling legislation for CACO permits the continued use of ORVs in the park. Until recently, vehicles used the 8.5-mile ORV corridor designated by the 1981/1985 ORV Management Plan to access recreational fishing sites. However, growing concern over nesting piping plovers (*Charadrius melodus*), federally designated as “threatened” in 1986, has resulted in a revision of the old ORV rule. The revised regulation closes a section of the original ORV corridor (Exit 8 to High Head North) and opens a previously restricted section of the outer beach for night fishing access (Coast Guard Beach to Longnook). This change could particularly increase ORV impacts to ocean beach invertebrates, which comprise a major portion of the natural beach community and an important part of the piping plover’s diet. Given that optimum foraging habitat and prey availability appear to be prime factors in piping plover nest site selection and reproductive success and that the new ORV rule has a mandated provision to monitor and report on changing ORV resource impacts and conditions, an investigation into the impacts of this altered ORV traffic on beach invertebrates is necessary.

### Research Needs.

The effects of ORV traffic on CACO’s beach invertebrates are currently being investigated in conjunction with the University of Rhode Island, and standards with which to measure ORV impacts are being determined. Upon completion of this initial research, methods for characterizing ORV impacts to various fauna need to be developed and a long-term monitoring program needs to be implemented to identify and track the potential adverse effects of ORV use on CACO wildlife. If adverse effects on beach fauna populations or habitat are detected, management recommendations will need to be made for changes to the ORV corridor locations, traffic routes and/or allowed periods of use within the seashore.



## Rare Invertebrates.

### Background.

Named for its “tiger-like” behavior of chasing down and capturing prey with its long mandible, the Northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) is listed as an endangered species in the state of Massachusetts and federally classified as threatened. Historically, the tiger beetle was found along the Atlantic coastline from Massachusetts to Virginia, including several beaches within Cape Cod National Seashore (Nothnagle, 1989). Today, however, it can only be found at the extremes of its former range, in the Chesapeake Bay area adjacent to Maryland and Virginia and on a single beach on one of Massachusetts’ offshore islands. Off-road vehicle (ORV) traffic is considered the prime cause of the beetle’s decline up and down the Atlantic coast. ORVs kill adult beetles and larvae directly by crushing them, and they also impact the species by continually damaging under-sand larval burrows, forcing the larvae to reduce their feeding time and to expend a considerable amount of energy restoring the burrows. In addition, the proximity of the larval burrows to the high-tide line in mid-summer increases their chance of being washed away; a severe storm or early season hurricane at this time could potentially wipe out the entire state population, making the probability of extinction for the Northeastern beach tiger beetle very high. The Massachusetts Natural Heritage & Endangered Species program initiated a reintroduction effort on a second Massachusetts beach in 2000; however, long-term monitoring and expanded management and reintroduction efforts are critically needed to ensure the species’ recovery.

In addition to the federally listed tiger beetle, six state-listed dragonfly and *Lepidoptera* species are also known to occur within the seashore (Carpenter, 1990; Mello, 1990), and because of the variable nature of invertebrate populations, many federal and/or state listed rare species may indeed be present that have not been located in previous studies. Without a comprehensive survey of CACO’s invertebrate populations and focused monitoring efforts to continuously evaluate the status of these organisms, large-scale impacts to these rare species will likely go unchecked, as occurred with the Northeastern beach tiger beetle (Knisley et al., 1987).

### Research Needs.

**Develop Monitoring Plan:** Development and implementation of a comprehensive long-term monitoring program for state listed rare invertebrates within CACO is critically needed for the protection of these species.

**Evaluate Northeastern Beach Tiger Beetle Reintroduction Potential:** The feasibility of reintroducing the Northeastern beach tiger beetle to the seashore needs to be assessed, with the cooperation of the Massachusetts Natural Heritage & Endangered Species program and the United States Fish and Wildlife Service recovery team. If reintroduction is deemed possible, CACO-specific management techniques should be developed and a reintroduction plan drafted.

## Rare Invertebrates, continued.

### Research Cited.

Carpenter, G. 1990. *Odonata* recorded in the Cape Cod National Seashore. Cape Cod Museum of Natural History, Brewster, MA.

Knisley, C.B., J.I Luebke, and D.R. Beatty. 1987. Natural history and population decline of the coastal tiger beetle, *Cicindela dorsalis dorsalis*. Virginia Journal of Science 38:293-303.

Mello, M.J. 1990. Survey of state-listed rare *Lepidoptera* on Cape Cod National Seashore Property. Lloyd Center for Environmental Studies, South Dartmouth, MA.

Nothnagle, P. 1989. Field survey of the tiger beetles (*Cincindelidae*, *Cicindela*) of the Cape Cod National Seashore. Windsor, VT.

## Red Fox, Small Mammal Prey and Shorebird Nest Predation.

### Background.

Red foxes (*Vulpes vulpes*) are a major predator on the eggs and young of ground-nesting birds in Cape Cod National Seashore's barrier beach habitats. The traditional



management response to piping plover (*Charadrius melodus*) and tern (*Sterna* sp.) nest predation has included predator removal and harassment, as well as efforts to reduce the vulnerability of nests by erecting fenced enclosures around the nest sites. A better understanding of the factors that influence nest predation is needed, however, in order to formulate more effective management strategies.

Many researchers have demonstrated that nest predation may be influenced by the abundance of alternate prey. An early study of predator-prey relationships in an Iowa waterfowl nesting area suggested that the nesting success of the blue-winged teal (*Anas discors*) was buffered by the abundance of small mammals and in Wisconsin, unpublished data also indicate that waterfowl nesting success is positively related to the abundance of small mammals. In Utah, radio-marked striped skunks (*Mephitis mephitis*) demonstrated a shift in foraging strategy from a "widely searching" to a "sit and wait" behavior that coincided with the increased availability of alternate prey later in the nesting season. That behavioral shift reduced the time skunks spent "widely searching," thus decreasing the probability of them encountering nests. In Sweden, red fox shifted from their main prey of small mammals to alternate prey such as willow grouse (*Lagopus lagopus*) and then to oldsquaw (*Clangula hyemalis*) eggs and ducklings following a crash in small mammal populations. Similarly, large variations in the breeding success of brent geese (*Branta bernicula*) in Russia appear to have been closely linked over a 33-year period with the abundance of small mammals. Given the importance of CACO as a nesting site for endangered shorebirds and the abundance of research worldwide that points to a relationship between small mammal abundance and waterbird nest success, a closer look at CACO's own predator-prey interactions is necessary in order to better manage its shorebird populations.

### Research Needs.

Study Red Fox Ecology: A study of red fox distribution and feeding ecology on the outer Cape is currently underway; however, credible scientific data is also needed on red fox habitat use, prey interactions and interactions with coyotes. Once sufficient data has been collected, management strategies should be developed to address red fox predation on piping plovers, inappropriate contact between foxes and park visitors (begging and frequent encounters in visitor areas), incidence of mange and pressure from other agencies to use lethal control methods.

## **Red Fox, Small Mammal Prey and Shorebird Nest Predation, continued.**

Study Small Mammal Abundance in Relation to Shorebird Nest Predation: The abundance and composition of small mammal species, hereby defined as shrews (*Blarina* sp.), voles (*Microtus* sp.), mice (*Peromyscus* sp. and *Mus* sp.) and rabbits (*Sylvilagus* sp.), needs to be determined in several habitat types, including sandplain grassland, coastal heathland, shrub thicket and oak-pine forest. Standard small mammal trapping techniques should be employed to determine habitat-specific abundance during the plover and tern nesting season (May-July). This data should then be compared to piping plover and tern nest predation rates in order to define the relationship between small mammal abundance and shorebird predation at CACO.

(See related project descriptions under “Shorebirds” and “Marsh-Dwelling Shorebirds.”)

## **Reptiles and Amphibians.**

### **Background.**

Despite their important roles as bioindicators and as integral components of terrestrial and aquatic ecosystems on Cape Cod, a comprehensive survey of reptile and amphibian populations within Cape Cod National Seashore has never been completed. Our current knowledge of local populations is based upon Lazell's (1972) surveys of the entire Cape and Islands region, Jones' surveys of CACO reptiles and amphibians (1992), Seipt's (1987) studies of state listed rare species, Portnoy's inventory of amphibians associated with temporary ponds (1986), the



Massachusetts Audubon Society's terrapin studies (Shipley and Prescott, 1989) and casual observations. A unique assemblage of amphibians and reptiles inhabits the outer Cape, due in part to the area's insular nature and glaciated past, and these animals' sensitivity to changes in their environment makes thorough, frequent monitoring especially crucial to their survival. Amphibian populations, in particular, have exhibited dramatic population declines worldwide, variously attributed to development impacts, global climate change, acid rain and attendant shifts in habitat, predation and/or competition. Major concerns on the Cape include habitat disruption associated with the effects of groundwater withdrawal on aquatic breeding and feeding areas, increased mortality from highway traffic (which is particularly acute during breeding migrations and dispersal from breeding sites), physical trampling of upland and wetland habitat, human recreational use of breeding pools and loss of upland habitat used by vernal pool breeders to residential development. Insular reptile populations are also highly vulnerable to development on the outer Cape, with heightened habitat isolation and direct mortality (e.g. road kills) inevitable as human activity increases. Complete, up-to-date surveys of CACO's amphibian and reptile populations are thus critically needed in order to protect these animals and their critical habitat.

### **Research Needs.**

An initial amphibian inventory was recently completed by the United States Geological Survey, and snake and aquatic turtle surveys are currently underway. Once these baseline inventories have been completed, long-term monitoring should be implemented in order to detect and track changes in the composition and abundance of these sensitive species over time, and to inform management decisions for their protection.

### **Research Cited.**

Jones, K. 1992. Cape Cod National Seashore reptile and amphibian survey. CACO Natural Resource Report 92-04. Cape Cod National Seashore, South Wellfleet, MA.



## Reptiles and Amphibians, continued.

Lazell, J.D. Jr. 1972. This Broken Archipelago: Cape Cod and the Islands' Amphibians and Reptiles. Quadrangle. New York, NY.

Portnoy, J.W. 1986. Vernal ponds of the Cape Cod National Seashore: Location, water chemistry, and *ambystoma* breeding biology. Cape Cod National Seashore, Wellfleet, MA.

Seipt, Irene. 1987. An inventory of the eastern spadefoot toad (*Scaphiopus holbrookii*) and the four-toed salamander (*Hemidactylium scutatum*) on outer Cape Cod. Center for Coastal Studies, Provincetown, MA.

Shiple, S. and R. Prescott. 1989. 1989 diamondback terrapin study of Wellfleet Harbor. Wellfleet Bay Wildlife Sanctuary, Massachusetts Audubon Society, South Wellfleet, MA.

## Seals.



### Background.

Centuries ago, large colonies of seals (*Halichoerus* and *Phoca* sp.) populated the shores and coastal waters of Cape Cod. In the mid-1800s, however, the seals, with their voracious appetite for fish, were viewed as a threat to the commercial fishing industry and were hunted for a bounty. Such hunting decimated the population of seals on Cape Cod. Not until 1962, when government sanctioned bounty hunting was finally put to an end in Massachusetts, did seals return to this area. These days, seals are protected under the Marine Mammal Protection Act of 1972 and increasing numbers of harbor and gray seals are once again year-round residents of Cape Cod. With the increase in animals has come an increase in human/seal interactions and, again, seals are

starting to be viewed as major competitors for food and space. Accurate information on the population, distribution and dominant prey species for western North Atlantic seals is crucial to the resolution of these renewed seal concerns and to the continued protection of the indigenous marine mammals.

### Research Needs.

A study of seal distribution and diet is currently underway at Race Point in Provincetown. Upon its completion, long-term seal monitoring is needed in order to assess changes in Cape Cod seal predation and population patterns over time.



## Shorebirds.

### Background.

Cape Cod National Seashore contains the largest colony of state listed rare least terns (*Sterna paradiseaea*) in New England, the largest colonies of state listed common and arctic terns (*Sterna hirundo* and *antillarum*) in Massachusetts, and a small but significant population of the federally endangered roseate tern (*Sterna dougallii*). CACO also provides significant nesting habitat for the federally threatened piping plover (*Charadrius melodus*). The breeding success of all of these species is negatively affected by off-road vehicles, pets, and native and feral predators, and pre-migratory feeding, essential to meeting the energy demands of these shorebirds during migration,



is often interrupted by pedestrians, pets and recreational activities with poorly known consequences. Because all of these shorebird species regularly come into contact with visitors to CACO, shorebird management requires intensive monitoring and protection, education of beach-users, enforcement of beach closures and wildlife regulations, and involvement with the media, off-road vehicle user groups and conservation organizations. The success of these management actions is key to these species' recovery. Much of the piping plover's recovery to date, for example, has been due to recovery in the state of Massachusetts, with CACO alone accounting for over ten percent of nesting pairs and over fifteen percent of plover productivity statewide in 1997 and 1998. While management efforts have thus been very successful in some areas, funding shortages have prevented adequate coverage of all shorebird nesting sites within the seashore.

Evolutionary adaptations of shorebirds that minimize the effects of predation include re-nesting, anti-predator behaviors and cryptic coloration of males and females. During the last 300 years, however, Cape Cod has been transformed from largely pristine wilderness to an intensively farmed area (Dunwiddie and Adams, 1995) and most recently, to a fragmented suburban landscape with dense human settlements. Coupled with these landscape changes have been changes in the composition of predator communities and in the abundance of nearly all predator species. Piping plovers and colonial nesting terns are presently exposed to different types of predator communities than existed during pristine times, and the birds' evolutionary defense mechanisms may no longer be adequate to protect them against these altered predation patterns. The American crow (*Corvus brachyrhynchos*) benefits greatly from agricultural and suburban developments, like those on Cape Cod, that provide artificial sources of food and trees for nesting (Schorger 1941). Not surprisingly then, American crows have been identified as a major cause of reproductive failure among piping plovers in CACO (Melvin et al., 1992). In 1994 and 1995, crows accounted for 67 percent of nests destroyed by predators (Jones, 1997). Further, Sullivan and Dinsmore (1990) found that egg predation was higher on bird nests placed within home ranges of breeding crows than on nests placed at random

## **Shorebirds, continued.**

locations outside of home ranges. While good information exists on crow ecology in upland habitats, research on American crow distribution, abundance and foraging ecology in Atlantic coast barrier beach ecosystems is needed to assess the threat of crow predation to threatened shorebird species.

### **Research Needs.**

**Monitor Nesting Shorebirds:** Existing breeding shorebird surveys need to be expanded to include North and South Beaches in Orleans and Chatham, and additional in-depth monitoring is needed to determine the causes of low tern and gull productivity at New Island in Nauset Marsh. Special attention should be given to monitoring all areas within the CACO boundaries on the dates requested by the Massachusetts Division of Fisheries and Wildlife, and census data and site information should be recorded in CACO's Geographic Information System to facilitate comparisons of nesting site locations and preferences over time.

**Analyze Nesting Habitat:** Data on beach characteristics have been collected in conjunction with piping plover monitoring over the last few years; however, additional data describing beach configuration and the spatial characterization of the intensity of nesting disturbances are needed in order to refine the definition of suitable habitat for plovers and to identify sites that meet this more specific criteria. Based on these findings, a habitat suitability index for shorebird nesting should be developed and tested.

**Assess Crow Depredation:** Research is needed to determine crow population parameters and productivity, to describe the foraging ecology of crows and to evaluate chronological changes in diet and movements that might affect predation rates on barrier beach nesting birds. Foraging ecology should be determined through radiotelemetry and visual monitoring, and breeding population densities should be estimated by intensive searches for nests. After these initial investigations have been completed, a long-term monitoring protocol should be developed for this species.

(See related project descriptions under “Red Fox, Small Mammal Prey and Shorebird Nest Predation” and “Marsh-Dwelling Shorebirds.”)

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## **Small Mammals.**

### **Background.**

Cape Cod National Seashore contains a number of relatively uncommon and insular terrestrial habitats, which may support an equally diverse and important mammalian



fauna; very little is known, however, about the abundance and distribution of small mammals within the park. A list of 28 species found within CACO has been developed (Jones, 1990) and rodent monitoring was recently conducted within the park's more common habitat types, but no voucher specimens exist in CACO's natural history collection and no park-wide small mammal reconnaissance has been conducted. A

geographically- and ecologically-complete inventory of CACO's small mammals, followed by long-term monitoring, is thus critically needed in order to assess the impacts of habitat fragmentation, annual small game hunting and other potential threats to the park's small mammal populations.

### **Research Needs.**

A small mammal inventory focusing on rodents in common habitat types was conducted in 2000 and 2001; however, quantitative and qualitative information on less common habitats (e.g. Atlantic white cedar and red maple swamps, beech forest) and other mammal groups (e.g. bats and other insectivores, rabbits, hares) is still needed. Long-term monitoring of all small mammals and small mammal habitats within the park is necessary in order to detect and track changes in these populations over time.

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## The Spotted Salamander.

### Background.

A significant component of Cape Cod's aquatic ecosystems, mole salamanders



(*Ambystomidae*) are considered highly vulnerable to acidification because of their near-exclusive use of temporary isolated wetlands for breeding. On the Cape, these breeding ponds are poorly buffered and the presence of sphagnum and pine, oak and maple litter results in highly acidic water (pH 4.5 to 5.5) with no reserve alkalinity and high color. Recent work by Portnoy (1990) has

demonstrated a high level of acid tolerance among Cape spotted salamanders (*Ambystoma maculatum*), but also a clear sensitivity of embryos to the combination of low pH and high concentrations of naturally occurring polyphenolic compounds. It is hypothesized that further reductions in the pH of highly colored sites due to acid rain (presently measured in CACO at pH 4.3) may substantially reduce embryonic survival and recruitment rates within isolated amphibian populations. Since the widely distributed spotted salamander is the only amphibian whose breeding abundance and embryonic survival have been systematically inventoried throughout Cape Cod National Seashore, a clear opportunity exists to use this baseline to evaluate the biological effects of potential acidification on this species.

### Research Needs.

Although adult salamanders are fossorial and therefore difficult to find, they do assemble to mate and oviposit at traditional breeding ponds and pond complexes within a fairly predictable time period in early April. Their reproductive output, if not their adult population size, is thus countable on an annual basis and work elsewhere has shown these egg counts to be a good index of breeding female abundance. When coupled with coincident water chemistry (pH, alkalinity, color and tannin-lignin), they should sufficiently reflect biologically significant changes in water chemistry over time. Long-term monitoring of CACO's spotted salamander population through the use of egg counts is thus needed to assess the population's overall health and response to changing water quality. If declines are suspected as a result of water chemistry changes, results should be confirmed with egg mortality studies to determine if the cause is indeed due to changes in embryonic mortality rates. Additional research may be necessary to assess survival and recruitment in the adult population.

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## Strandings.

### Background.

Records of marine mammal strandings on Cape Cod date back hundreds of years – in fact, harvesting stranded whales for oil formed the basis of Wellfleet’s early economy – and cetacean and sea turtle strandings still regularly occur within Cape Cod National Seashore. Many of the stranded animals are federally listed as threatened or endangered



species and, in some cases, the cumulative loss of these individuals to stranding may have an impact on the population as a whole.

Marine mammal strandings are typically caused by illness or injury, but human interaction (through fishing gear entanglement or marine debris ingestion, ship strike and even gunshots), stormy weather, and the swift, extreme tides in Cape Cod Bay also appear to be factors. Typically, cetaceans migrate to the area to feed on the rich stores of plankton and fish in the bay or at the nearby Stellwagen Bank National Marine Sanctuary. When the animals become fouled in gear, normal breathing, feeding and movement may be impaired or stopped completely; weakened by this inability to feed or breath properly and exhausted from the excess drag created by trailing, tangled gear, entangled marine mammals may be unable to prevent themselves from washing ashore. Heavy seas following storms can also leave animals exhausted, disoriented, or separated from their group, and the rapidly changing bay tides can leave dolphins and porpoises stranded in marshes or mudflats where, hours before, they were feeding plentifully on fish that had come in on the high tide. The very process of stranding can be catastrophic for a cetacean, even for one who has simply lost its way and become trapped by an outgoing tide. Although many stranded mammals come ashore alive, the beaching prompts a cascade of physiological changes, often resulting in shock and death.

Mass strandings, involving anywhere from a few to several hundred animals, regularly occur in several parts of the world (primarily Australia, New Zealand, and Cape Cod), yet so far there is no universally accepted, comprehensive explanation for this phenomenon.

In many cases, these animals show no obvious signs of health problems other than those resulting from the stranding itself. It is hypothesized that, because the species typically involved in mass strandings are extremely social, the bonds that hold groups together are perhaps strong enough to supercede the survival instincts of individual animals. Once animals start coming ashore at a mass stranding event, it is extremely difficult to stop the process from continuing and escalating. Affected animals will relentlessly follow one another ashore, even when there is clear access to open water. Although mass strandings typically occur during winter months and at times of severe weather, they can in fact occur at any time of year and under any conditions.

## **Strandings, continued.**

Sea turtles in our region do not typically come ashore unless they are seriously debilitated. During the warm summer months, several turtle species ride the Gulf Stream north from the Caribbean Sea and the Gulf of Mexico to feed on the abundant food supply in Cape Cod Bay. As water temperatures drop in the late fall and winter, the turtles' body temperatures can fall below their tolerable limits. In a condition similar to hypothermia, the animals become unable to swim or feed and become increasingly susceptible to dehydration and disease. Instead of migrating south to warmer waters, "cold-stunned" turtles often become trapped in Cape Cod Bay, drifting helplessly with the winds and currents until they wash ashore. During a typical winter, several dozen live sea turtles wash ashore on Cape beaches. If these turtles are recovered and treated soon enough, they have a good chance of survival.

## **Research Needs.**

Cape Cod National Seashore works closely with the National Marine Fisheries Service, the New England Aquarium, the Center for Coastal Studies and Massachusetts Audubon Society's Wellfleet Bay Wildlife Sanctuary to respond to live strandings on the outer Cape. Live animals are assessed, and then either transported to institutions for rehabilitation, returned to the water with guidance from experienced rehabilitation personnel or, in some cases, euthanized. Necropsies are performed on dead animals when appropriate. Further research into the causes of mass strandings is needed, as is a long-term evaluation of the success of current rescue techniques.

## **Terrestrial Birds.**

### **Background.**

Landbirds, because of their high body temperature, rapid metabolism rate and high ecological position on most food webs, may be excellent indicators of the effects of environmental change in terrestrial ecosystems. Furthermore, their diurnal nature, discrete reproductive seasonality, intermediate lifespan, and abundance and diversity in virtually all terrestrial habitats favor widespread monitoring of their population and demographic information. It is not surprising, therefore, that landbirds have been selected by the National Park Service to receive high priority for monitoring because of their potential as sensitive indicators of local, regional and global environmental change.



The importance of Cape Cod as a breeding and migration stopover site for neotropical migrant landbirds and many other state listed rare bird species is well-known, but not quantified. In the past, available data on terrestrial birds at Cape Cod National Seashore has focused on migratory and wintering periods without a qualitative or quantitative database on nesting landbirds. Although extensive research has been done on CACO's shorebird populations, no complete inventory of CACO's terrestrial birds exists, and as a result management decisions must regularly be made with minimal information about, and without consideration for, terrestrial bird populations. In addition to standard baseline information about the terrestrial bird species occurring within the seashore, avian productivity and survival data is needed to: identify the stage(s) in bird life cycles at which changes in population dynamics are taking place; define thresholds and trigger points for research and/or management actions regarding landbird population declines; facilitate the planning of management actions and conservation strategies to reverse population declines; and aid in evaluating the effectiveness of such actions. Landbird population performance will also be a useful measurement in evaluating the success of land management actions designed to mimic natural landscape patterns, such as prescribed burns, and in evaluating the effects of specific human-related and natural events on terrestrial bird populations.

### **Research Needs.**

**Inventory Nesting Birds:** Until recently, landbird monitoring at CACO was limited to one annual five-hour survey along a 25-mile stretch of road from Eastham to North Truro. In 2001, however, a more expansive two-year terrestrial breeding bird survey was initiated. Following this initial inventory, long-term monitoring is needed to track changes in CACO's landbird population and to evaluate the success of CACO management actions intended to protect these species.



## **Terrestrial Birds, continued.**

**Monitor Migrant Species:** The Beech Forest in Provincetown is a well-known stopover spot for migratory landbirds, attracting hundreds of birdwatchers in late May every year. Amateur ornithologists have observed a decline in the Beech Forest's bird populations over recent years, but such changes have not been scientifically quantified. Migratory bird populations in the Beech Forest, and other CACO areas where geography and habitat concentrate migrants, need to be monitored in order to detect and mitigate population declines.

**Monitor Avian Productivity and Survival:** A five-year project investigating the productivity and survival of a number of target avian species, including both neotropical migrants and permanent residents, began in 1999. Continued long-term monitoring following the project's completion in 2003 is necessary in order to determine annual changes and long-term trends in the population and demographic parameters of CACO's landbirds.

## **The White-Tailed Deer.**



### **Background.**

Although white-tailed deer are one of the most popular and important terrestrial mammals within Cape Cod National Seashore, relatively little ecological or biological information exists about the park's deer population. Hunting is a traditional activity on the outer Cape, and the Massachusetts Division of Fisheries and Wildlife manages the population by setting harvest quotas and hunting season dates. Deer are harvested during the fall with three-week archery, one-week shotgun and two-day primitive firearms seasons. The annual limit is two deer per season; one antlerless deer per year can be taken by permit only. Other than evaluating the sex and general age characteristics of the harvest, however, no monitoring is conducted. Data on the deer and hunting efforts are critically needed to identify and adequately evaluate anthropogenic and natural changes to CACO's white-tailed deer population.

### **Research Needs.**

A baseline survey of deer abundance and distribution in CACO, followed by long-term monitoring, is needed. Harvest rate, sex, age, weight, antler-beam diameter of yearling males and female reproductive rates should be included in the monitoring protocol. Specific questions to be addressed include:

1. Are deer numbers increasing in CACO, as suggested by the substantial increase in the annual deer harvest over the last ten years?
2. Are distribution patterns for white-tailed deer changing in the seashore?
3. Are hunter efforts changing and, if so, how are those changes affecting the abundance and composition of the herd? What role does hunting play in regulating the deer population?
4. How are deer impacted by increasing residential development in, and visitation to, the outer Cape?
5. How will changes in landscape and vegetation influence deer population dynamics?
6. What are the ecological effects of increasing deer densities? Are plant species being eliminated as a result of browsing by deer? Are deer adversely affecting forest-nesting birds?

(See related project descriptions under "Hunting Impacts.")



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